U.S. Manufacturing in International Perspective

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Summary

The health of the U.S. manufacturing sector has long been of great concern to Congress. The decline in manufacturing employment since the start of the 21st century has stimulated particular congressional interest. Members have introduced hundreds of bills intended to support domestic manufacturing activity in various ways. The proponents of such measures frequently contend that the United States is by various measures falling behind other countries in manufacturing, and they argue that this relative decline can be mitigated or reversed by government policy.

This report is designed to inform the debate over the health of U.S. manufacturing through a series of charts and tables that depict the position of the United States relative to other countries according to various metrics. Understanding which trends in manufacturing reflect factors that may be unique to the United States and which are related to broader changes in technology or consumer preferences may be helpful in formulating policies intended to aid firms or workers engaged in manufacturing activity. This report does not describe or discuss specific policy options.

The main findings are:

- The United States remained the largest manufacturing country in 2010, although its share of global manufacturing activity has declined in recent years.
- Manufacturing output has grown more rapidly in the United States over the past decade than in most European countries and Japan, although it has lagged China, Korea, and other countries in Asia.
- Employment in manufacturing has fallen in most major manufacturing countries over the past two decades. The United States saw a disproportionately large drop between 2000 and 2010, but its decline in manufacturing employment since 1990 is in line with the changes in several European countries and Japan.
- U.S. manufacturers spend far more on research and development (R&D) than those in any other country, but manufacturers' R&D spending is rising more rapidly in China, Korea, Mexico, and Taiwan.
- A large share of manufacturing R&D in the United States takes place in high-technology sectors, particularly pharmaceutical and electronic instrument manufacturing, whereas in other countries a far greater proportion of manufacturers' R&D outlays occur in medium-technology sectors such as motor vehicle and machinery manufacturing.

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Introduction

The health of the U.S. manufacturing sector has long been of great concern to Congress. The large decline in manufacturing employment since the start of the twenty-first century has stimulated particular congressional interest. Members have introduced hundreds of bills intended to support domestic manufacturing activity in various ways. The proponents of such measures frequently contend that the United States is in some way falling behind other countries in manufacturing, and argue that this relative decline can be mitigated by government policy.

Examining U.S. manufacturing in isolation sheds little light on the causes of changes in the structure of the manufacturing sector. While some of those changes may be a result of factors specific to the United States, others may be attributable to technological advances, changed consumer preferences, or macroeconomic forces such as exchange-rate shifts. This report is designed to inform the debate over the health of U.S. manufacturing by examining recent changes in the manufacturing sector in comparative perspective. It does not describe or discuss specific policy options.

The charts and tables on the pages that follow depict the position of the United States relative to other major manufacturing countries according to various metrics. Not all countries compile information on each subject, so it is not possible to show data for the same set of countries on each chart. This report draws on data from a number of sources, and has certain unavoidable statistical problems of which the reader should be aware.

Despite meaningful progress in standardization, countries define "manufacturing" in different ways; in particular, some associate manufacturing with factory production, while others may label a self-employed artisan as a manufacturing worker. Some countries have sophisticated sampling systems to collect data about production and employment from firms and households, whereas others rely heavily on estimates drawn from macroeconomic models or collect data only from a non-random subset of enterprises, such as those located in major cities. International comparisons of compensation data are especially difficult because of national differences in taxation and employee benefits. Complicating matters further, the organizations that compile statistics obtained from national governments may adjust the raw data in different ways to improve compatibility, such that certain figures used to prepare this report may not be identical to those published by national statistical services.

Additionally, analysis of trends in manufacturing is complicated by often arbitrary distinctions between manufacturing and non-manufacturing activity. If, for example, a manufacturing firm owns the trucks that deliver its goods to customers, statisticians will count the truck drivers as manufacturing-sector workers, and their wages will be included in the manufacturing sector's value added. If, however, the manufacturer instead contracts with a separate trucking company to deliver its goods, statisticians will consider the truck drivers to be transport-sector workers and their wages will be included in transport-sector value added, making the manufacturing sector appear smaller—even though there has been no change in the total amount of labor or the tasks performed.

All of these factors argue for caution in the use of these data, and warn against unwarranted assumptions of precision.

How the U.S. Manufacturing Sector Ranks

The standard measure of the size of a nation's manufacturing sector is not manufacturers' sales, but rather their value added. Value added attempts to capture the economic contribution of manufacturers in designing, processing, and marketing the products they sell.

At the level of an individual firm, value added can be calculated as total sales less the total value of purchased inputs, such as raw materials and electricity. The intuition behind this calculation is that a firm that purchases raw materials and processes them only slightly may have substantial sales, but its manufacturing efforts will not have transformed the materials in ways that significantly increase their value. Alternatively, a firm's value added can be measured as the sum of its employee compensation, business taxes (less subsidies), and profits.

The aggregate value added of a country's manufacturing sector cannot be determined simply by adding up the value added of its manufacturers. If a domestic manufacturer uses inputs from its plants abroad, those inputs contain value added by the firm, but not within the United States. Calculating total value added in manufacturing thus requires adjustments for imported parts and components incorporated into the output of domestic factories, and also for domestic products that were exported and used in a foreign plant to make products that were subsequently imported into the United States.[1]

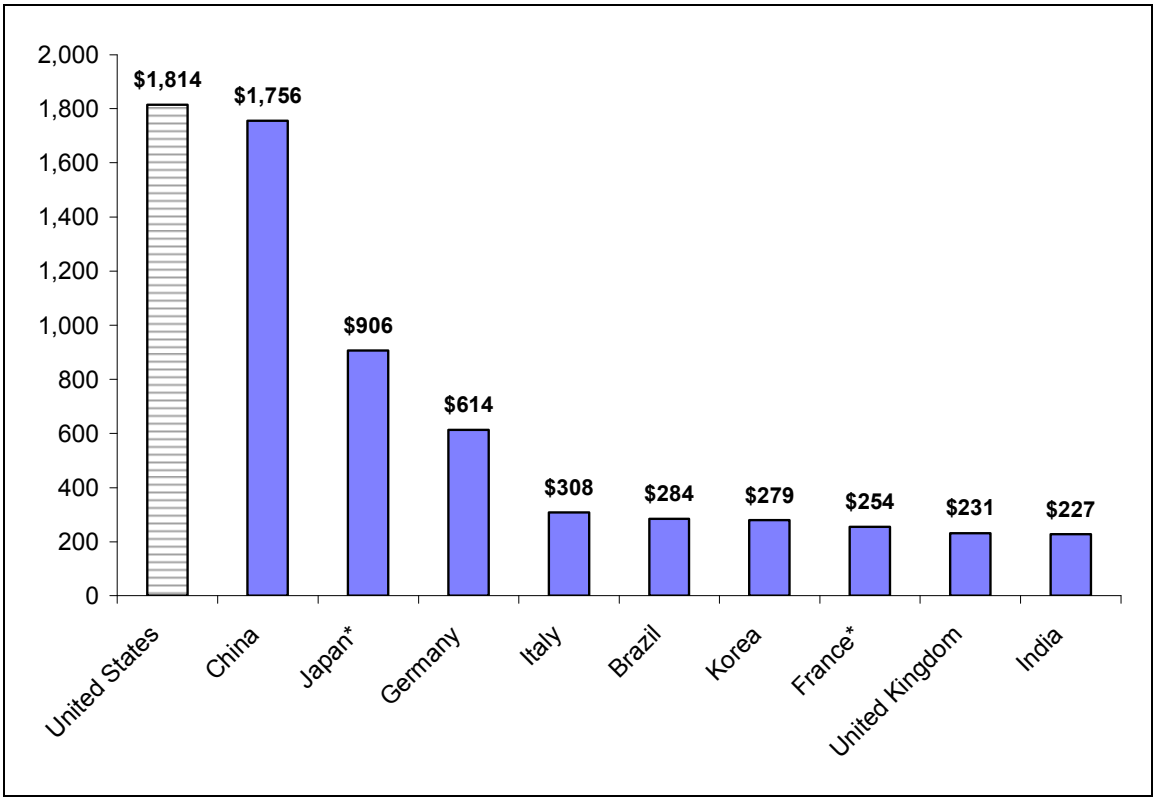
According to World Bank estimates, the United States retained its position as the largest manufacturing nation in 2010, with value added of $1.8 trillion, closely followed by China. No 2010 data are available for Japan, the third-ranking country, but based on 2009 Japanese data the manufacturing sectors in the United States and China are both roughly twice the size of Japan's (see **Figure 1**). Germany is the only other country whose manufacturing sector is more than one-fifth the size of those in the United States and China.[2]

[1] For more on the changing nature of value added in manufacturing, see CRS Report R41712, *"Hollowing Out" in U.S. Manufacturing: Analysis and Issues for Congress*, by Marc Levinson.

[2] See http://data.worldbank.org/indicator/NV.IND.MANF.CD. The data used here are standardized and hence may differ from those produced by national statistical services; for example, the World Bank estimates U.S. manufacturing value added at $1.814 trillion in 2010, whereas the U.S. Bureau of Economic Analysis has published an estimate of $1.702 trillion; see http://www.bea.gov/iTable/iTable.cfm?ReqID=5&step=1. The U.S. Census Bureau, which uses a different method of calculation, gives 2010 manufacturing value added as $2.19 trillion; see *2010 Annual Survey of Manufactures*, item AM1031AS101, http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

Figure 1. Countries with Largest Manufacturing Sectors by Value Added

(Billions of U.S. dollars, 2010)

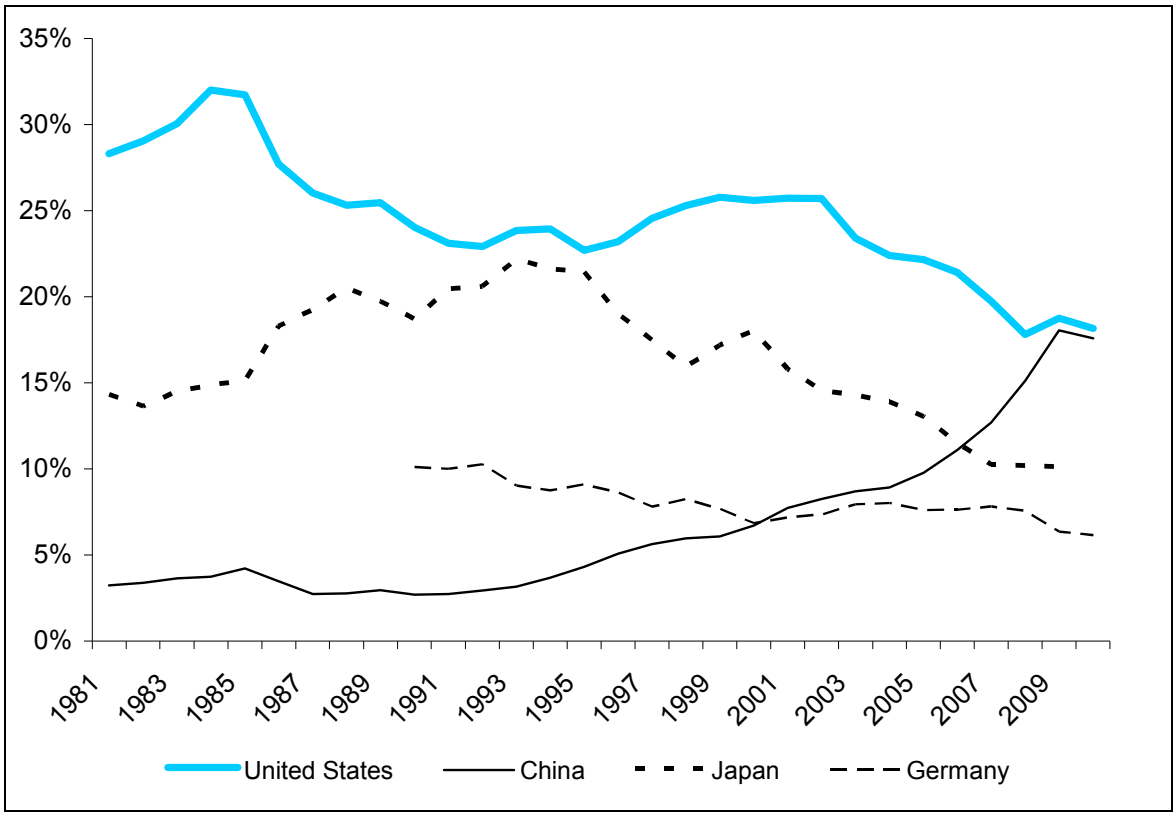


Source: World Bank, http://data.worldbank.org/indicator/NV.IND.MANF.CD.

Note: * Data for Japan and France are for 2009.

The U.S. share of global manufacturing value added has declined over time, from nearly one-third in the early 1980s to just short of one-fifth today (see **Figure 2**). Similarly, Japan's share of global manufacturing value added has contracted from 22% in 1993 to around 10% now, and Germany's has fallen from 10% to 6%. These smaller shares are a consequence of the very rapid increase in manufacturing activity in emerging economies, notably China, and do not indicate absolute declines in manufacturing value added in those countries. Manufacturing value added in the United States, as measured by the Bureau of Economic Analysis in inflation-adjusted 2005 dollars, rose 75% from 1990 to 2010 and 16% from 2000 to 2010, although it was lower in 2010 than at the onset of the most recent recession in 2007.

Figure 2. Selected Countries' Shares of Global Manufacturing Value Added



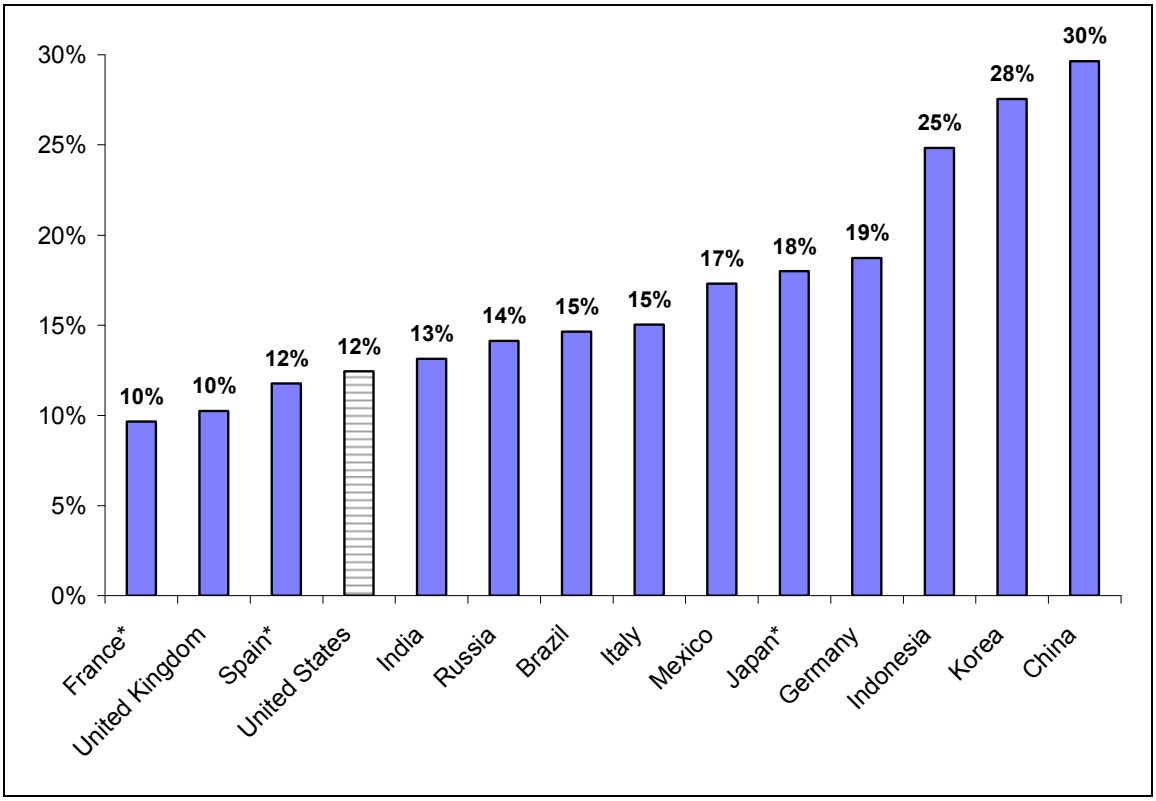
Source: World Bank, http://data.worldbank.org/indicator/NV.IND.MANF.CD.

Manufacturing value added amounted to 12.4% of total U.S. gross domestic product (GDP) in 2010, according to World Bank estimates. Manufacturing is more significant in the United States, relative to the size of the economy, than in the United Kingdom and France, but much less important than in Japan, Germany, Indonesia, Korea, and China (see **Figure 3**). Chinese manufacturing value added accounted for 29.6% of its economy's total output in 2010, according to the World Bank.

In this respect, it is important to note that a high ratio of manufacturing value added to GDP is not necessarily a sign of economic vibrancy. To the contrary, a high ratio may indicate that various policies or practices, such as labor regulations, credit subsidies, or protection from imports, are standing in the way of a reallocation of capital and labor from manufacturing to other sectors in which they might contribute more to economic growth.

Figure 3. Share of Manufacturing in National Economies

(Manufacturing value added as percent of gross domestic product, 2010)



Source: World Bank, computed from data available at http://data.worldbank.org/indicator/NY.GDP.MKTP.CN and http://data.worldbank.org/indicator/NV.IND.MANF.CN.

Note: * Data for France, Japan, and Spain are for 2009. Figures are rounded to nearest percentage point.

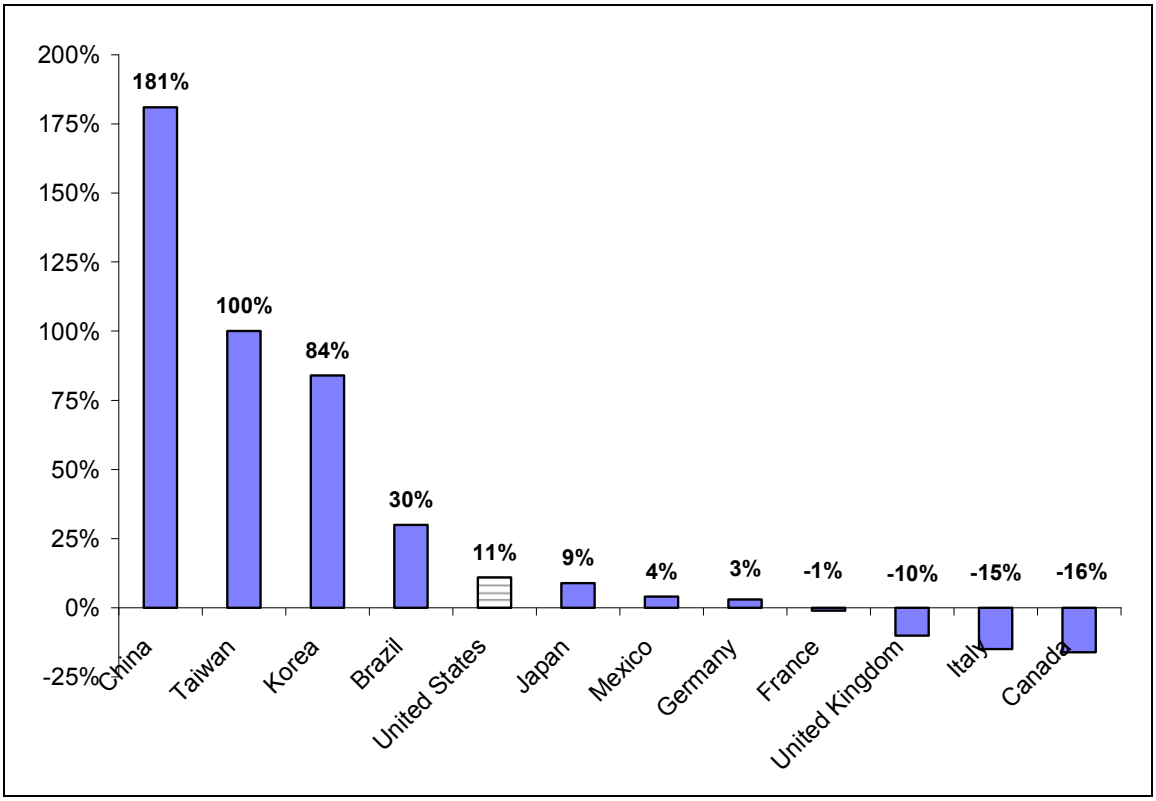
Despite its relatively low rank in manufacturing as a share of GDP, the United States appears to have outperformed most other wealthy countries in the growth of manufacturing value added over the past decade. U.S. value added in manufacturing, adjusted for inflation, rose 11 percent between 2000 and 2010, according to estimates by the U.S. Bureau of Labor Statistics (BLS). Japan and Germany had lower growth in manufacturing value added during that period, after adjusting for inflation, while France, the United Kingdom, Italy, and Canada saw declines in value added.[3] Separate data from the World Bank show that China and Taiwan had much faster growth in value added than the United States, after adjusting for inflation (see **Figure 4**).[4]

[3] U.S. Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends: Underlying Data Tables," October 13, 2011. The BLS estimates of change in real value added cited in this paragraph differ from the figures presented by the Bureau of Economic Analysis, cited above, as BLS has made adjustments for international compatibility.

[4] http://data.worldbank.org/indicator/NV.IND.MANF.KN.

Figure 4. Change in Value Added in Manufacturing, 2000-2010

(Adjusted for inflation in each respective country)



Sources: Derived from U.S. Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends: Underlying Data Tables," October 13, 2011. Figures for China, Mexico, and Taiwan derived from World Bank, http://data.worldbank.org/indicator/NV.IND.MANF.KN.

Note: Data for France include mining.

The United States has also performed well in manufacturing, compared to other high-income economies, when viewed over a longer time period. From 1990 through 2010, the only high-income countries with faster growth in manufacturing value added were Finland and Sweden.

Additionally, data on inflows of foreign investment suggest that the United States has been an attractive manufacturing location relative to other high-income countries in recent years. Over the 2007-2009 period, 34.6% of foreign direct investment coming into the United States went into the manufacturing sector, compared to 21.1% in Italy, 18% in the United Kingdom, 11.4% in France and Japan, and less than 10% in Germany and Korea.[5] Comparative data are not available regarding the extent to which foreign direct investment finances construction of new manufacturing facilities as opposed to acquisition of existing facilities.

Data on capital investment in manufacturing are compiled by the Organisation for Economic Co-operation and Development (OECD), a group of 34 nations, most with relatively high per-capita incomes. Investment data are available for only a few countries. These indicate that gross

[5] OECD International Direct Investment Statistics, "Foreign direct investment: flows by industry," http://doi:10.1787/data-00334-en.

investment in fixed manufacturing capital, such as factories and equipment, accounts for a lower share of GDP in the United States than in the other wealthy countries for which data are available (see **Figure 5**). Gross fixed capital formation across the entire economy is lower relative to GDP in the United States than in most of these countries,[6] but the United States also devotes a smaller share of gross fixed capital formation to manufacturing than the other countries, with the exception of France.[7]

Interpreting the comparative data on investment in manufacturing is problematic. A high ratio of gross fixed capital formation to output is not necessarily positive from an economic point of view; if such investment is generating a low return, then high capital investment could indicate inefficient use of capital. The relatively low level of gross investment in the United States might therefore indicate that U.S. manufacturers pay greater attention to return on capital than their counterparts in other countries. Another explanation might be that U.S. manufacturers face comparatively few obstacles to contracting fabrication or assembly work to manufacturers abroad, whereas other nations may have policies in place to promote domestic fabrication and assembly or to discourage foreign sourcing. Also, it is important to note that the definition of gross fixed capital used by the OECD appears to exclude software, which may represent a greater share of investment by U.S. manufacturers than by those in other countries.[8]

Gross fixed-capital formation in manufacturing measures only additions to the capital stock less subtractions for capital stock destroyed or sold into other sectors of the economy, with no adjustment for the depreciation of the existing capital stock. It therefore does not measure the extent to which the capital stock used in manufacturing changes from year to year. According to the OECD, the *net* stock of fixed capital in U.S. manufacturing rose 3% from 2005 to 2008, after adjusting for inflation, but no comparable data are available for other major manufacturing countries.[9]

[6] http://stats.oecd.org, "National Accounts at a Glance: 6. Capital," indicator K1S: Consumption of fixed capital, percentage of GDP.

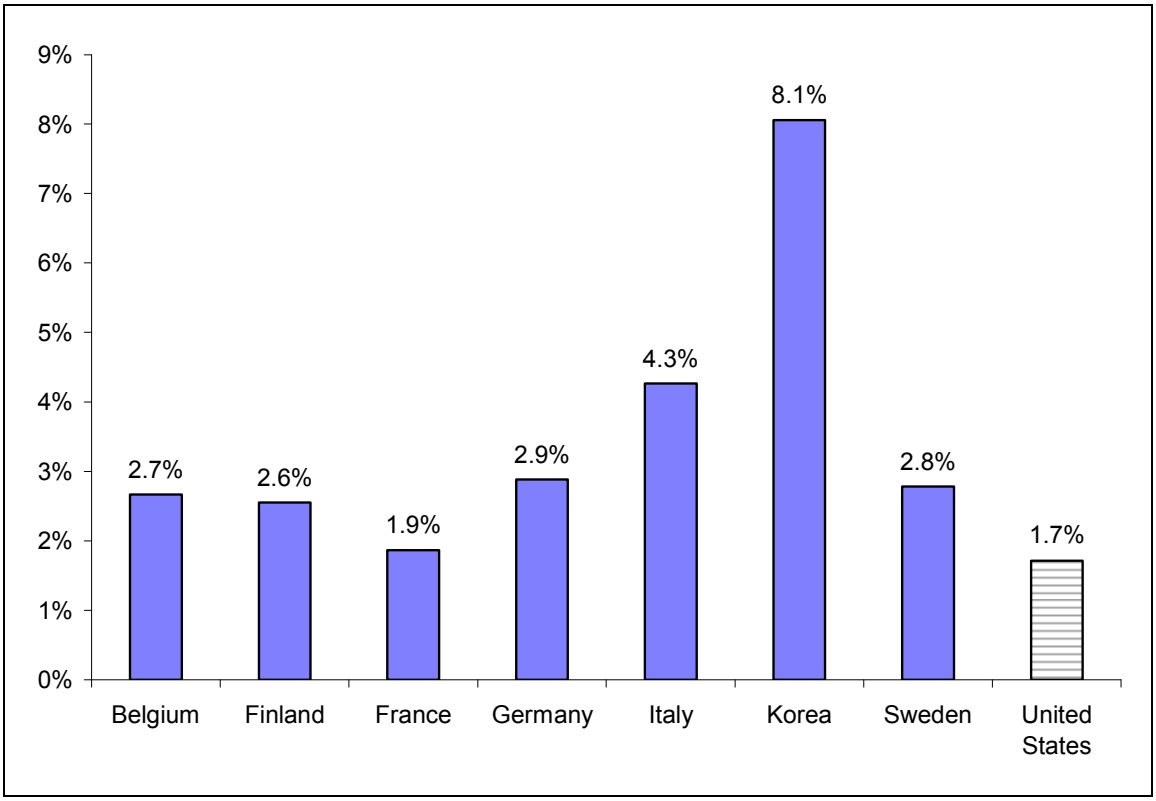
[7] Some 9.6% of U.S. fixed-capital formation in 2008 occurred in the manufacturing sector, compared to 8.5% in France. The highest proportion among the countries for which data are available was 27.5% in Korea. See OECD, "Detailed National Accounts: Capital formation by activity," *OECD National Accounts Statistics* (database), http://doi: 10.1787/data-00009-en.

[8] OECD uses the definition established by the United Nations Statistics Division, which reads: "Gross fixed capital formation is measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non-produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realised by the productive activity of institutional units." http://unstats.un.org/unsd/snaama/glossresults.asp?gID=34.

[9] OECD, "Detailed National Accounts: Fixed assets by activity and by type of product," *OECD National Accounts Statistics* (database), http://doi: 10.1787/data-00009-en.

Figure 5. Gross Fixed Capital Formation in Manufacturing

(Share of GDP, 2008)



Source: OECD, National Account Statistics, "Detailed National Accounts: Capital formation by activity," and "Gross Domestic Product," http://stats.oecd.org/BrandedView.aspx?oecd_bv_id=na-data-en&doi=data-00008-en.

The Role of Services in Manufacturing

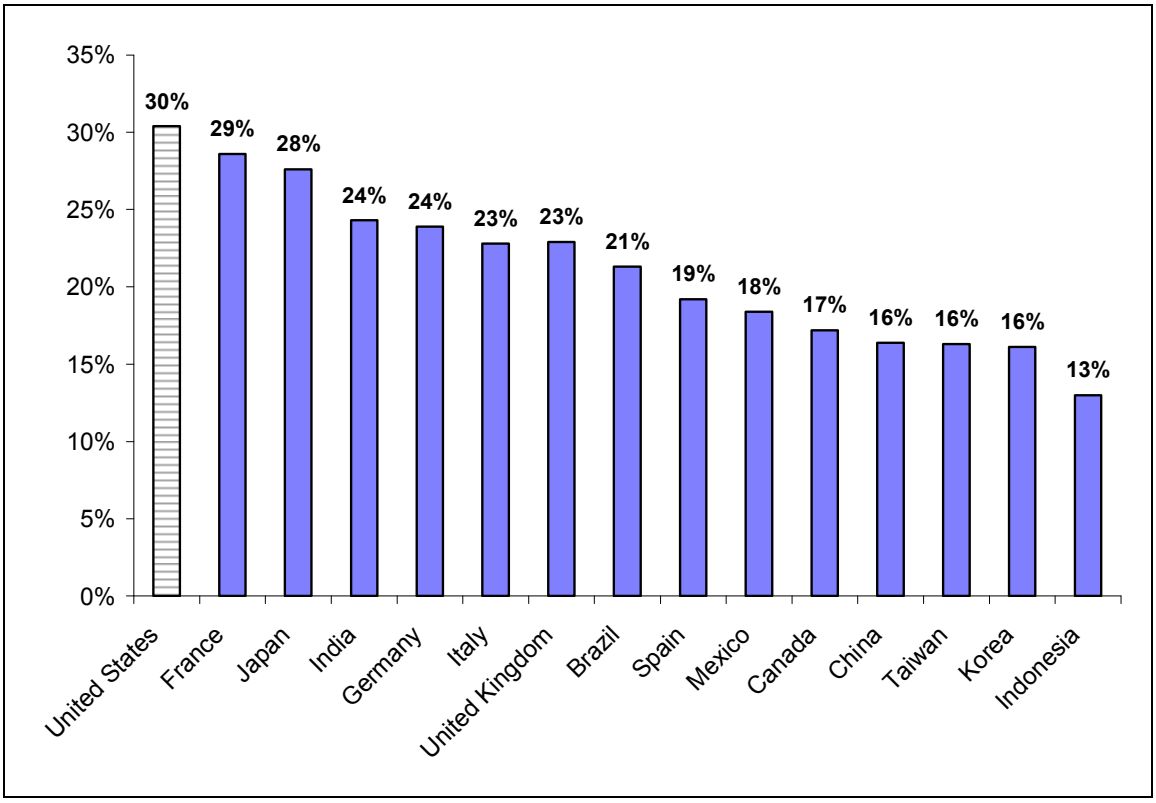
Measuring manufacturing activity is not without problems, largely because of the imperfect line between manufacturing and services. U.S. statistical agencies, for example, consider activities occurring at establishments whose principal business is manufacturing to be manufacturing, regardless of the specific tasks involved. Similarly, activities occurring at establishments whose principal business is services are considered service activities.

The following three examples will illustrate the statistical confusion that can result. If a manufacturing facility designs and then fabricates a product, the design activities generally count as value added in manufacturing and the workers engaged will be tabulated as manufacturing employees. If the design is created within the manufacturing firm but at a location where no physical production occurs, it could conceivably count as either a manufactured product or a service-sector product. If the manufacturer purchases the design from a specialist design firm, the value added in the design process will be credited to the service sector, and the workers involved will be considered service-sector employees. In all three cases, total employment and total value added are identical; all that differs is the economic sector to which the employment and value added are attributed.

Efforts to measure the value of manufacturing-related services more accurately are still in their infancy. Such data as are available indicate that service-sector inputs incorporated into manufactured products account for a larger share of manufacturing value added in the United States than in any other major economy (see **Figure 6**). Further, the service-sector share of the total value added of manufactured goods increased faster in the United States than in any of the 37 other countries studied between 1995 and 2005.

Figure 6. Service-Sector Inputs into Manufacturing

(Service-sector value added in manufactured goods as percentage of total value added of manufactured goods, 2005)

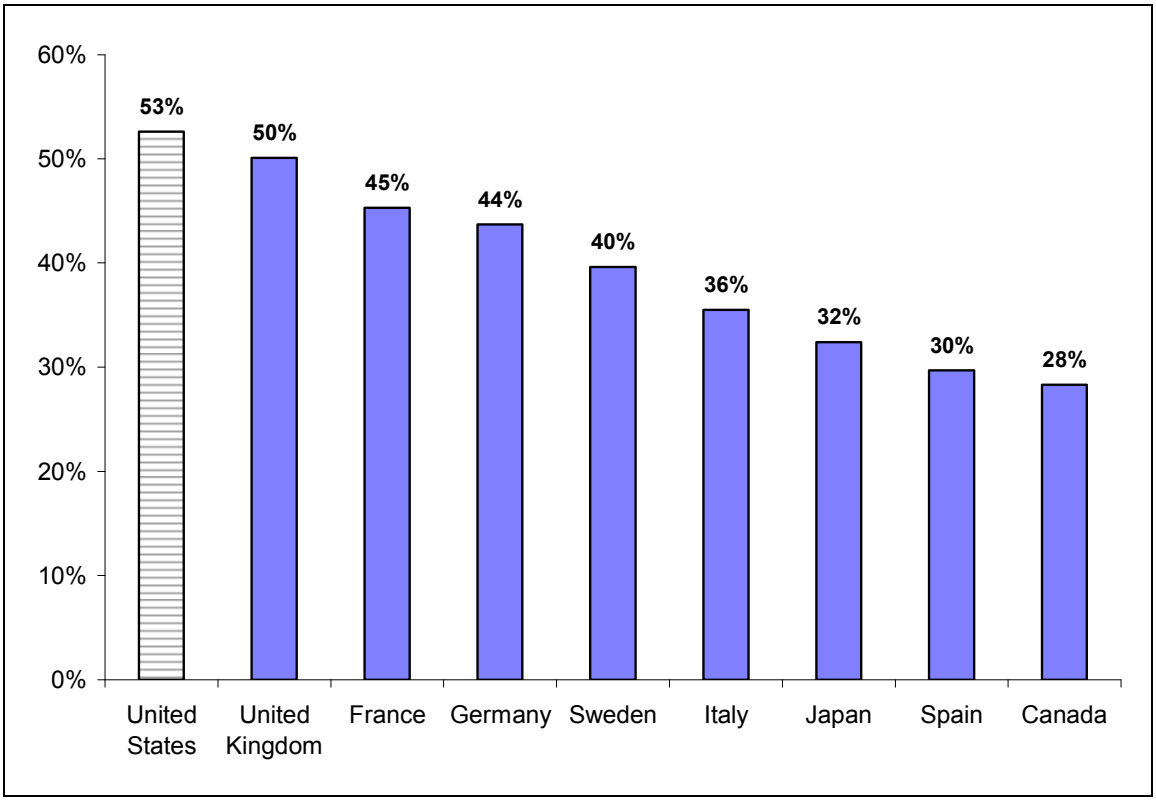


Source: Organisation for Economic Co-operation and Development (OECD), STAN Input-Output Database, May 2011, http://dx.doi.org/10.1787/888932487628.

The figures illustrated in **Figure 6** show only the importance of services purchased by manufacturers from outside firms. One possible interpretation of these data is that U.S. manufacturers are less vertically integrated than those in other countries, such that they more frequently contract with outside providers for services rather than producing them in-house. However, data on the occupations of manufacturing workers argue against this interpretation. In 2008, more than half of all Americans employed within the manufacturing sector worked in service occupations, such as management, technical support, and sales (see **Figure 7**). This is a far greater proportion than in other OECD economies. The relatively high service-intensity of U.S. manufacturing is thus evident within manufacturing firms as well as in their purchases of inputs from outside firms.

Figure 7. Services-Related Occupations in Manufacturing Industries

(Percentage of all employees in manufacturing, 2008)



Source: OECD Science, Technology and Industry Scorecard, 2011.

Notes: Swedish data are for 2007. Service-related occupations include (1) legislators, senior officials, and managers; (2) professionals; (3) technicians and associate professionals; (4) clerks; and (5) service workers and shop and market sales workers as defined in the International Standard Classification of Occupations, 1988.

In combination, the data in **Figure 6** and **Figure 7** suggest that U.S. manufacturers may be relatively advanced, in comparison to those in other countries, when it comes to automating routine production work, and therefore employ a smaller proportion of their workers in production operations. A related interpretation of these data would be that U.S. manufacturers' output contains a higher proportion of non-physical value, such as intellectual property, than the output of other countries, possibly implying that U.S. manufacturers produce more advanced products. Another possibility is that U.S. manufacturers make greater use of certain services, such as legal, tax, and accounting services, than manufacturers in other countries.

Manufacturing Work

International comparisons of manufacturing employment trends are hampered by inadequate data, particularly for emerging economies. Among the top-ranking manufacturing countries, China, Brazil, and India do not report complete information on manufacturing employment at the

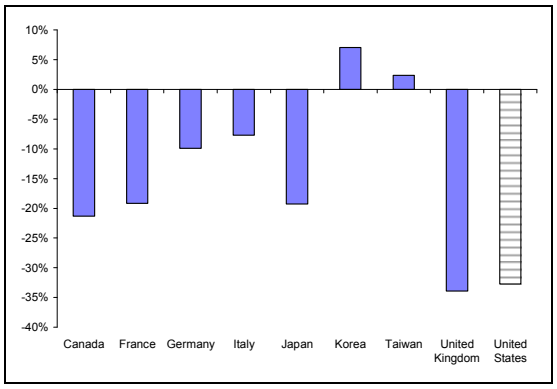
national level. Mexico has a nationwide statistical sampling program, but due to definitional and methodological changes a consistent time series is available only since 2009.[10]

Manufacturing employment in the United States fell by roughly one-third from 2000 through 2010. Among the major manufacturing countries for which data are available, only the United Kingdom saw a larger decline in manufacturing employment over that period (see **Figure 8**). Looked at over a 20-year period, however, manufacturing employment fell by approximately the same percentage in the United States as in France, Germany, and Japan, and much less than in the United Kingdom (see **Figure 9**).

These figures indicate that the diminished importance of manufacturing as a source of jobs is a widespread phenomenon and is not limited to the United States.[11] However, the timing of decline has differed from country to country. Some countries experienced sharp manufacturing employment declines during the 1990s. In other countries, including the United States and Canada, employment in manufacturing held fairly steady during the 1990s but declined quite steeply from 2000 to 2010.

Figure 8. Manufacturing Employment

(Percentage change, 2000-2010)

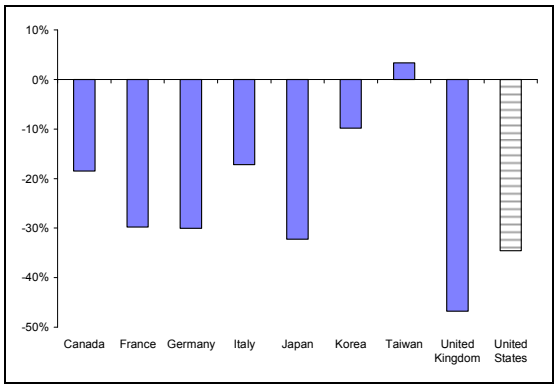


Source: Derived from U.S. Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends: Underlying Data Tables," October 13, 2011.

Note: Data for France include mining.

Figure 9. Manufacturing Employment

(Percentage change, 1990-2010)



Source: Derived from U.S. Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends: Underlying Data Tables," October 13, 2011.

Note: Data for France include mining.

The international comparison of manufacturing employment is somewhat different if viewed in terms of hours worked rather than by the number of workers. By this metric, the United States

[10] On manufacturing employment in China, see Judith Banister and George Cook, "China's employment and compensation costs in manufacturing through 2008," *Monthly Labor Review*, March 2011, p. 39, http://www.bls.gov/opub/mlr/2011/03/art4full.pdf. On manufacturing employment in India, see Jessica R. Sincavage, Carl Haub, and O.P. Sharma, "Labor costs in India's organized manufacturing sector," *Monthly Labor Review*, May 2010, p. 3, http://www.bls.gov/opub/mlr/2010/05/art1full.pdf. Recent Mexican data from the Instituto Nacional de Estadística y Geografía are available at http://dgcnesyp.inegi.org.mx/cgi-win/bdiecoy.exe/445?s=est&c=25534.

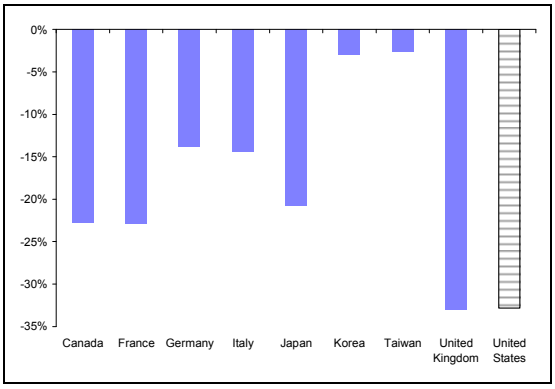
[11] These data are compiled by the U.S. Bureau of Labor Statistics (BLS) and adjusted for consistency. For most countries, the manufacturing sector is as defined by the International Standard Industrial Classification system, but data for Canada and the United States are in accordance with the North American Industry Classification System. The data for France include some mining activity. For details, see the BLS detailed technical notes available at http://www.bls.gov/fls/intl_prod_tn.pdf.

and the United Kingdom had approximately the same rates of decline between 2000 and 2010, far beyond that in other countries (see **Figure 10**). Over the past two decades, however, France, Japan, and the United Kingdom all had larger declines in hours worked in manufacturing than did the United States, and Germany was on a par with the United States (see **Figure 11**).

As with manufacturing employment, the timing of declines in hours worked in manufacturing has varied among countries. France, Germany, Italy, Japan, and Korea all had much sharper declines in manufacturing hours worked than did the United States between 1990 and 2000, but the United States experienced a far more rapid decline than those countries between 2000 and 2010.

Figure 10. Manufacturing Hours Worked

(Percentage change, 2000-2010)

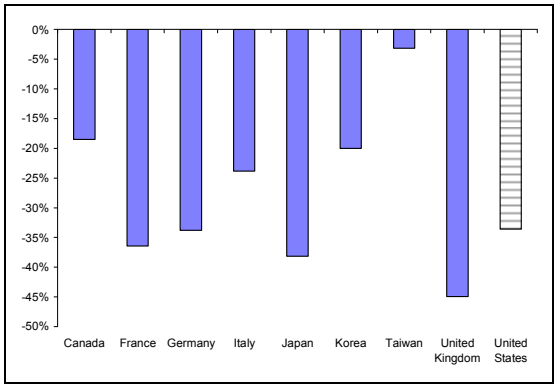


Source: Derived from U.S. Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends: Underlying Data Tables," October 13, 2011.

Note: Data for France include mining.

Figure 11. Manufacturing Hours Worked

(Percentage change, 1990-2010)



Source: Derived from U.S. Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends: Underlying Data Tables," October 13, 2011.

Note: Data for France include mining.

Whether the measure in the number of workers employed in the sector or the number of work hours, the United States is not unique in experiencing a decline in the need for labor in the manufacturing sector. Even in Korea and Taiwan, where manufacturing output has expanded far more rapidly than in the United States, factories require fewer total hours of labor than was the case a decade ago.

The reduced demand for labor is directly related to improved labor productivity in manufacturing. Manufacturing labor productivity increased much more rapidly in the United States between 2000 and 2010 than in Canada, European countries, or Japan, as measured by real output per hour of manufacturing labor (see **Figure 12**). Taiwan and Korea both had greater improvement in manufacturing labor productivity than the United States.

The strong improvement in U.S. labor productivity in manufacturing has several causes. One is manufacturers' large investments in automation, which have eliminated many routine assembly jobs; less than 40% of the workers in U.S. manufacturing establishments are now directly engaged in production. A related factor is the rapid increase in education levels among U.S. manufacturing workers, some 28% of whom possess college degrees.[12] A third cause of

[12] On occupations and education within the manufacturing sector, see CRS Report R41898, *Job Creation in the Manufacturing Revival*, by Marc Levinson.

improvement in average manufacturing productivity is the relatively rapid growth of certain areas of U.S. manufacturing in which labor productivity is extremely high. These include instruments manufacturing, in which output grew 28% from 2000 to 2010, and aerospace manufacturing, which expanded output 21% over the same period, even as total U.S. manufacturing output fell 3%.[13]

In part, however, the measured improvement in labor productivity in manufacturing also reflects the rapid shrinkage of low-productivity manufacturing activities over the course of the past decade. During this period, many manufacturers moved routine assembly work abroad, either to their own factories or to those of contract suppliers. The reduction of U.S. import barriers encouraged apparel imports and the resulting reduction of domestic capacity in the low-productivity apparel industry. As U.S. plants with below-average productivity closed, the average labor productivity of the remaining manufacturing plants necessarily increased even in the absence of productivity improvements.[14]

Similarly, the very rapid increases in manufacturing labor productivity measures in Korea and Taiwan likely reflect the closure of low-productivity manufacturing as well as the expansion of capital-intensive manufacturing and rising education levels among manufacturing workers. For example, Korea's exports of apparel, the product of a comparatively low-productivity industry, declined from $5 billion in 2000 to $1.6 billion in 2010, and Taiwan's fell from $3 billion to $1 billion over the same period.[15] As the jobs involved in producing such goods were eliminated, the average productivity of those countries' manufacturing workers would have risen even without growth in high-productivity sectors.

At the other extreme, Italy, which saw only a small drop in manufacturing employment over the decade, registered absolute declines in manufacturing value added and in output per hour worked. This may indicate that restructuring low-productivity operations has been a challenge for Italian manufacturers, or may be the result of other government policies to retain employment. Italy's export data provide some evidence of this: after adjusting for the appreciation of the euro, Italy's exports of apparel rose 9% between 2000 and 2010.[16]

[13] Output changes are calculated from annual figures published in the Federal Reserve Board G.17 release, "Industrial Production and Capacity Utilization."

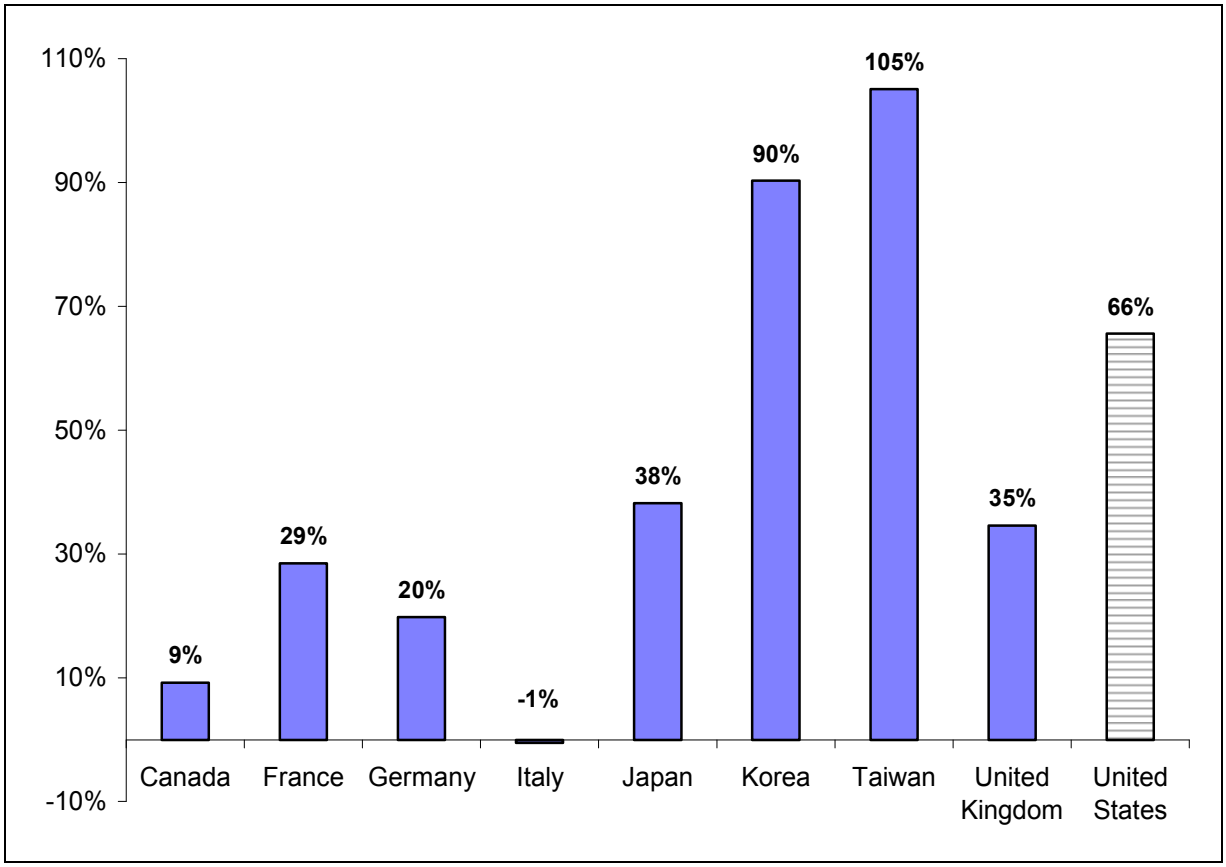
[14] In general, the manufacturing industries with the lowest productivity growth are those in which it has proven most difficult to automate production processes to increase output per worker hour. The apparel and footwear industries are notable in this respect. From 1973 to 2001, multifactor productivity grew at an annual rate of 0.9% for all U.S. manufacturing, but at only 0.7% for apparel and 0.3% for leather and leather products. For detailed data on this subject, see U.S. Bureau of Labor Statistics, "Multifactor Productivity in U.S. Manufacturing and in 20 Manufacturing Industries, 1949-2001," February 10, 2004, http://www.bls.gov/mfp/tables.htm,and "Manufacturing Sector and NIPA-level Manufacturing Industries KLEMS multifactor Productivity Tables by Measure," August 11, 2011, http://www.bls.gov/mfp/mprdload.htm.

[15] Korea and Taiwan data were taken from World Trade Organization statistics database, http://stat.wto.org/StatisticalProgram/WSDBViewData.aspx?Language=E.

[16] In current U.S. dollars, Italian apparel exports rose from $13.4 billion in 2000 to $20 billion in 2010, a 49% increase. See http://stat.wto.org/StatisticalProgram/WSDBViewData.aspx?Language=E. Over the same period, the euro appreciated approximately 40% against the dollar.

Figure 12. Real Output per Labor Hour in Manufacturing

(Percentage change, 2000-2010)



Source: U.S. Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends: 2010 Data Tables," December 1, 2011.

Average compensation per employee in U.S. manufacturing was $34.74 per hour in 2010, a 36% increase since 2000.[17] U.S. hourly manufacturing labor costs were lower than those in 13 of 33 countries studied by the Bureau of Labor Statistics (BLS). Due in good part to exchange-rate changes, average compensation per hour expressed in U.S. dollar terms has been rising more slowly in the United States than in most other major manufacturing countries (see **Table 1**). For example, hourly compensation in manufacturing in Brazil rose an average of 6.7% annually between 1997 and 2010, compared to a 3.2% annual rate of increase in the United States, but after exchange-rate changes are factored in, Brazilian manufacturing labor costs declined relative to those in the United States.

Accurate nationwide data on manufacturing compensation costs in China and India are not available. BLS estimates average manufacturing compensation in China to have been $1.36 per hour in 2008,[18] but it warns that this estimate is not as robust as those for other countries.[19] With

[17] "Compensation" includes pay for time worked, employee benefits, and labor-related taxes net of subsidies.

[18] See Banister and Cook, "China's employment and compensation costs in manufacturing through 2008."

[19] BLS News Release, "International Comparisons of Hourly Compensation Costs in Manufacturing, 2010," December 21, 2011, http://www.bls.gov/news.release/ichcc.nr0.htm.

respect to India, BLS estimates average compensation in formal manufacturing establishments to have been $1.17 in 2007, but cautions that this figure overstates average compensation as it pertains to only about 20% of the country's manufacturing workers.[20] Because data from China and India are not comparable to those from other countries, they are not included in **Table 1**.

Table 1. Hourly Compensation Costs in Manufacturing

(U.S. dollar basis)

	Direct Pay, 2010	Total Compensation Costs, 2010	Average Annual Percentage Change, 1997-2010
Brazil	$6.85	$10.08	2.8%
Canada	$27.64	$35.67	5.0%
France	$27.61	$40.55	3.8%
Germany	$34.24	$43.76	3.2%
Italy	$23.84	$33.41	4.2%
Japan	$26.29	$31.99	2.8%
Korea	$13.36	$16.62	4.5%
Mexico	$4.30	$6.23	4.6%
Taiwan	$7.13	$8.36	1.3%
United Kingdom	$25.05	$29.44	3.6%
United States	$26.27	$34.74	3.2%

Source: U.S. Bureau of Labor Statistics, "International Comparisons of Hourly Compensation Costs in Manufacturing, 2010," December 21, 2011, Tables 2 and 3.

Notes: "Direct Pay" includes vacation pay, bonus payments, and employer contributions to employees' savings funds. "Total Compensation Costs" includes pensions, disability insurance, sick leave, health insurance, severance pay, other social insurance expenditures, and taxes on payrolls or employment. "Average Annual Percentage Change" is calculated in terms of U.S. dollars and incorporates the effects of exchange-rate changes.

The data on average hourly compensation costs can be misleading, as they are not adjusted for differences in the industrial mix. In most countries, including the United States, labor costs vary greatly among industries; the average hourly wage of U.S. workers who make household furniture is less than $16 per hour, whereas average hourly wage in aircraft manufacturing exceeds $40.

The most recent U.S. government data on comparative compensation costs within individual industries, which date to 2007, show U.S. costs to be lower than those in major European countries, although well above those in emerging economies (see **Table 2**). The more detailed data that would be required to correct for national differences in the products manufactured by these industries are not available.

[20] Sincavage, et al, "Labor costs in India's organized manufacturing sector."

Table 2. Hourly Compensation Costs in Selected Manufacturing Industries

(U.S. dollar basis, 2007)

	Wood Products	Textiles	Chemicals	Machinery	Motor Vehicles
Brazil	$3.64	$4.58	$13.89	$8.78	$13.08
Canada	$27.92	$23.53	$37.10	$34.06	$41.11
France	$28.13	$28.66	$50.81	$39.09	$42.73
Germany	$35.11	$36.94	$66.76	$54.17	$67.14
Italy	$24.57	$29.23	$44.87	$34.31	$33.36
Japan	$17.49	$19.62	$34.59	$26.78	NA
Korea	$13.80	$12.02	$24.07	$18.42	$21.66
Mexico	$2.06	$3.04	$9.06	$4.65	$5.29
Taiwan	$5.78	$6.66	$10.91	$7.38	$9.08
United Kingdom	$26.66	$29.68	$46.93	$37.57	$41.65
United States	$20.67	$21.17	$45.76	$32.08	$33.77

Source: U.S. Bureau of Labor Statistics, ftp://ftp.bls.gov/pub/special.requests/ForeignLabor/aeindustrynaics.txt.

Note: Industry definitions are not identical in all countries.

Technology and Research in Manufacturing

High-technology manufacturing has been a particular focus of public-policy concern for many years. There is no standard definition of high-tech manufacturing, but commentators have long asserted that high-technology production has especially beneficial economic spillovers.[21] Although definitions of "high-tech industry" vary, the OECD considers that manufacturing of pharmaceuticals; office, accounting, and computing machinery; radio, television, and communications equipment; medical, precision, and optical instruments; and aircraft and spacecraft is particularly technology-intensive, based on those industries' research and development (R&D) expenditures and on the amount of R&D embodied in their products.[22] It is important to note in this context that some industries that may have a considerable technological component, such as automobile and machinery manufacturing, are not considered high-technology industries by the OECD.

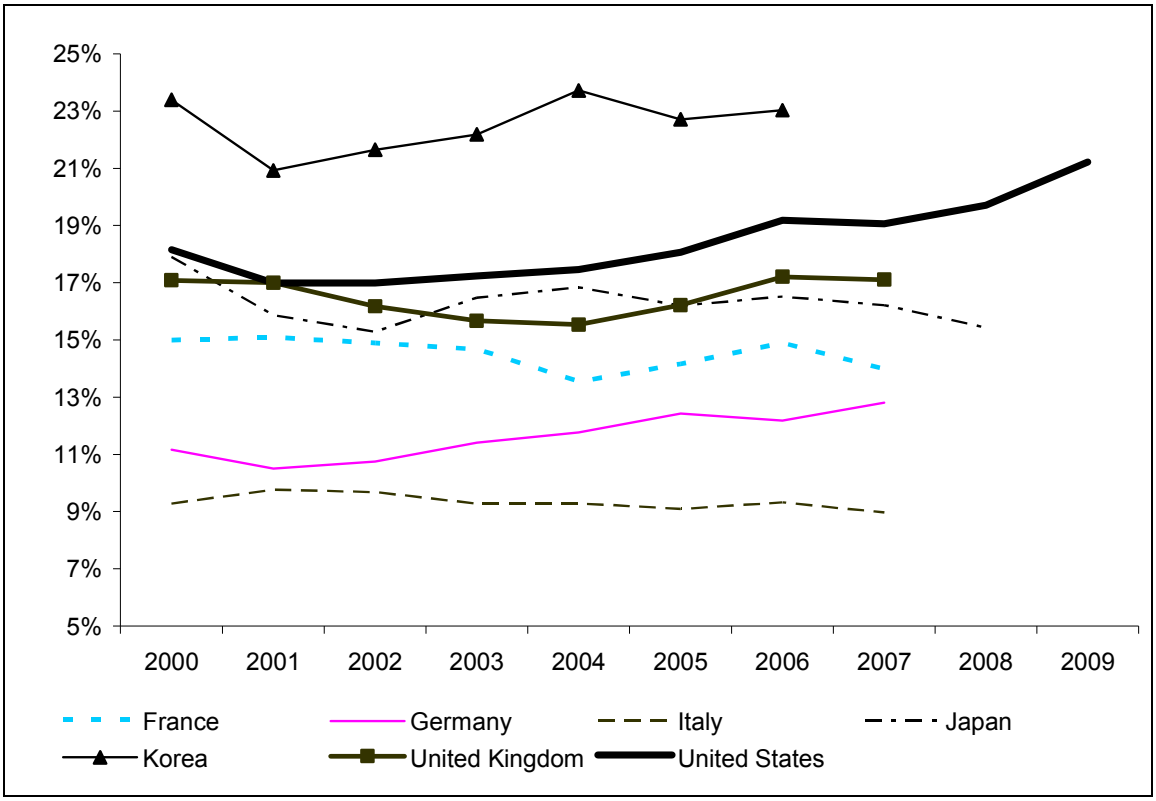
The United States derives a greater share of manufacturing value added from high-tech industries than is the case in most other OECD member countries (see **Figure 13**). Moreover, the share of value added represented by high-technology sectors has been rising in the United States, whereas it has been stable or declining in many other countries.

[21] See, for example, Stephen S. Cohen and John Zysman, *Manufacturing Matters: The Myth of the Post-Industrial Economy* (New York, 1987), p. 106, and Lester Thurow, *Head to Head: The Coming Economic Battle Among Japan, Europe, and America* (New York, 1992), pp. 45-51.

[22] These sectors correspond to United Nations International Standard Industrial Classifications 2423, 30, 32, 33, and 353. For details, see OECD, "ISIC Rev. 3 Technology Intensity Definition," July 7, 2011, p. 1, http://www.oecd.org/dataoecd/43/41/48350231.pdf.

Figure 13. Importance of High-Tech Industries

(Share of country's manufacturing value added)



Source: OECD STAN database, http://stats.oecd.org/Index.aspx?DatasetCode-STAN08BIS&lang=en.

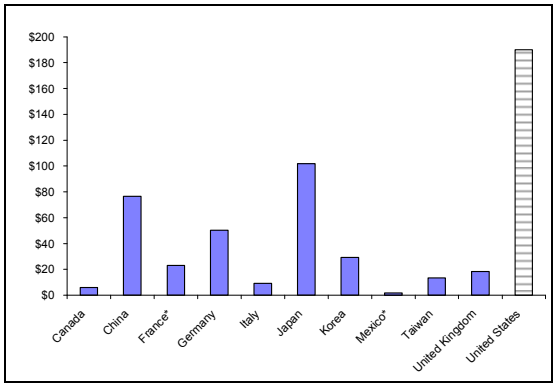
Manufacturers in the United States spend far more on research than those in any other major industrial country. Adjusting for differences in purchasing power, spending on manufacturing research and development was nearly twice as high in the United States as in Japan in 2007, and almost four times the level of Germany (see **Figure 14**).[23]

Although far less manufacturing R&D occurs in countries that have industrialized more recently, R&D spending in those countries has been growing at a very rapid rate (see **Figure 15**).

[23] These figures include expenditures by manufacturers, whatever the original source of the funds. For technical background, see OECD, "The OECD Analytical BERD (ANBERD) Database," August 5, 2011, http://www.oecd.org/dataoecd/52/23/47840198.pdf.

Figure 14. R&D in Manufacturing, 2008

(Billions of U.S. dollars at purchasing power parity)

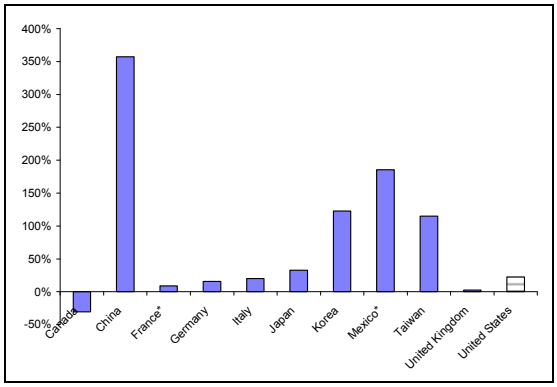


Source: OECD STAN database, "STAN R&D expenditures in Industry," http://stats.oecd.org/index.aspx.

Note: * Mexico data are for 2007.

Figure 15. Growth in Manufacturing R&D

(Change in real local currency, 2000-2008)



Source: OECD STAN database, "STAN R&D expenditures in Industry," http://stats.oecd.org/index.aspx.

Note: * Mexico data are for 2000-2007.

Manufacturers have been responsible for approximately 70% of all R&D conducted by businesses in the United States in recent years. This is similar to the proportion in Italy, but far lower than in Germany, Japan, and Korea, where manufacturers account for 88%, on average, of all business-financed R&D. Conversely, the service sector is relatively more important in undertaking research and development in the United States than in many other countries. The most notable exception is the United Kingdom, where service companies account for three-fifths of all business R&D spending.[24]

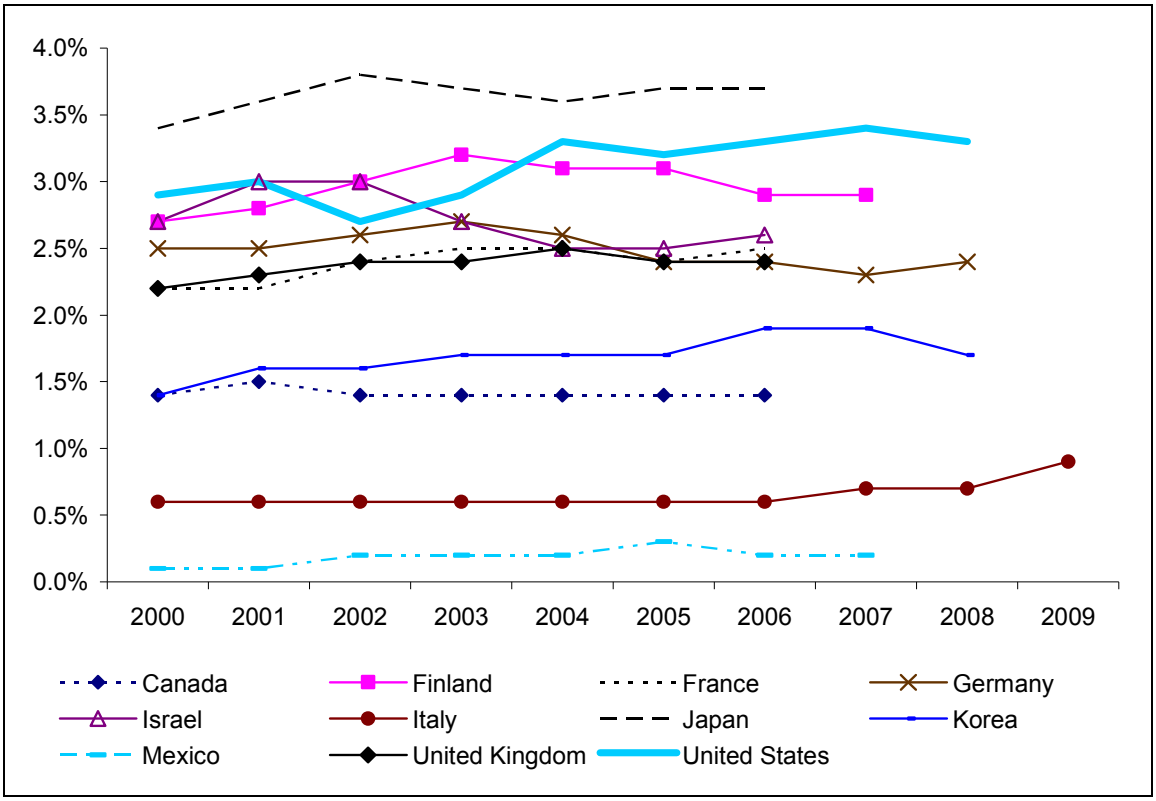
The research intensity of U.S. manufacturing increased during the first decade of the twenty-first century, indicating that U.S. manufacturers are devoting a growing share of their revenue to R&D. In 2000, U.S. manufacturers spent 2.9% of sales on research and development, a figure that rose to 3.3% by 2008. The only country in which manufacturers' R&D spending has been growing at a faster rate is Korea. U.S. manufacturers devote a greater proportion of their revenue to R&D than those in any other country save Japan, including some countries renowned for their relatively large high-technology sectors, such as Finland and Israel (see **Figure 16**). [25]

[24] OECD, Science, Technology and R&D Statistics, "Business enterprise R-D expenditure by industry," http://www.oecd-ilibrary.org/content/data/data-00183-en.

[25] The data discussed in this paragraph measure research and development expenditures by manufacturers as a percentage of their sales. OECD also compiles statistics on the ratio of R&D spending to value added. However, these statistics can be problematic for single-year, cross-country comparisons, as a decline in an industry's profitability can reduce its value added, increasing the ratio of R&D outlays to value added even if no additional research is undertaken.

Figure 16. Manufacturers' Research Intensity in Selected Countries

(R&D spending by manufacturers as percentage of sales)



Source: OECD, STAN indicators: R&D intensity of manufacturing sectors, http://www.oecd-ilibrary.org/industry-and-services/data/stan-oecd-structural-analysis-statistics/stan-indicators-2009_data-00031-en.

One possible reason for national differences in R&D intensity in manufacturing is differences in the composition of the manufacturing sector. Industries such as aircraft and spacecraft manufacturing and electronic instrument manufacturing are among the most research-intensive in every country, and, all other things equal, countries in which these sectors are relatively large may be expected to have greater R&D intensity in manufacturing than countries in which they are less important.

Table 3 provides an alternative cross-country comparison of R&D spending by manufacturers by breaking out R&D intensity by industry. The data pertain to 2006, the most recent year for which comparable data are available for all countries shown. The table illustrates the fact that manufacturers in the United States are more research-intensive than those in other countries only in selected industries, such as electronic instruments. In other industries, foreign manufacturers spend comparatively more on R&D than those in the United States. For example, Japanese manufacturers of office, accounting, and computing machinery devote a greater share of sales to R&D than those in any other country, and Italy, whose manufacturers generally are much less R&D-intensive than those in other countries, appears to have particularly extensive industry research related to aerospace manufacturing.

Table 3. Comparative Research and Development Spending by Industry

(R&D outlays by manufacturers as a percentage of sales, 2006)

	Canada	France	Germany	Italy	Japan	Korea	United Kingdom	United States
All manufacturing	1.4%	2.5%	2.4%	0.6%	3.7%	1.9%	2.4%	3.3%
Pharmaceuticals	11.9%	8.7%	10.4%	1.5%	15.0%	2.5%	24.9%	22.5%
Office, accounting, computing machinery	10.9%	7.9%	4.1%	1.1%	28.7%	3.9%	0.4%	11.0%
Electrical machinery	1.3%	3.5%	1.3%	0.5%	8.8%	1.4%	3.3%	2.0%
Instruments	NA	7.1%	6.6%	2.4%	14.4%	2.2%	3.6%	18.0%
Motor vehicles	0.5%	4.7%	4.4%	1.8%	4.3%	2.8%	1.9%	3.4%
Aircraft and spacecraft	6.3%	5.2%	10.4%	12.5%	4.2%	9.0%	10.7%	11.3%

Source: OECD, STAN indicators: R&D intensity of manufacturing sectors, http://www.oecd-ilibrary.org/industry-and-services/data/stan-oecd-structural-analysis-statistics/stan-indicators-2009_data-00031-en.

Table 4 confirms the implication of **Table 3** that manufacturers' R&D spending is targeted quite differently in different countries. In the United States, a much larger proportion of manufacturing R&D occurs in the pharmaceutical sector than is the case elsewhere, with the exception of the United Kingdom. The instruments sector, including medical equipment and process-control equipment as well as navigational, testing, and measuring equipment, is also disproportionately important in the United States. By contrast, the motor vehicle sector accounts for a significantly smaller share of manufacturers' research and development activity in the United States than in other countries for which data are available.

Table 4. Manufacturers' R&D Spending by Sector

(Percentage of total research and development spending by manufacturers)

Country	Year	Pharma	Telecoms	Instruments	Motor Vehicles	Other Trans. Equ.	Other
France	2007	6.9%	14.8%	9.7%	11.0%	19.6%	38.1%
Germany	2008	8.3%	8.0%	8.0%	36.9%	5.7%	33.1%
Italy	2008	6.9%	10.9%	6.9%	16.0%	15.6%	43.6%
Japan	2008	10.9%	20.5%	5.8%	19.3%	0.5%	42.9%
Korea	2008	2.8%	51.6%	3.0%	15.0%	2.4%	25.3%
United Kingdom	2008	N/A	5.6%	11.1%	17.1%	23.6%	N/A%
United States	2006	22.8%	18.1%	13.1%	9.7%	11.7%	24.7%

Source: OECD, Science, Technology and R&D Statistics, "Business enterprise R-D expenditure by industry," http://www.oecd-ilibrary.org/content/data/data-00183-en.

The United States ranks third among OECD member countries, following only Ireland and Finland, in the proportion of manufacturing R&D that occurs in high-technology sectors. In the United States, OECD reports, 69% of manufacturers' total R&D spending in 2007 occurred in high-technology sectors and 22% in medium-technology sectors. In Germany, by contrast, 60%

of manufacturers' R&D spending occurred in medium-technology sectors, such as motor vehicle and machinery manufacturing, and the corresponding figure for Japan was 45%.[26]

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[26] OECD Science, Technology and Industry Scoreboard 2011, "Business R&D in the manufacturing sector by technological intensity," Figure 6.8.2, http://www.oecd-ilibrary.org/sites/sti_scoreboard-2011-en/06/08/index.html?contentType=/ns/Chapter,/ns/StatisticalPublication&itemId=/content/chapter/sti_scoreboard-2011-62-en&containerItemId=/content/serial/20725345&accessItemIds=&mimeType=text/html.